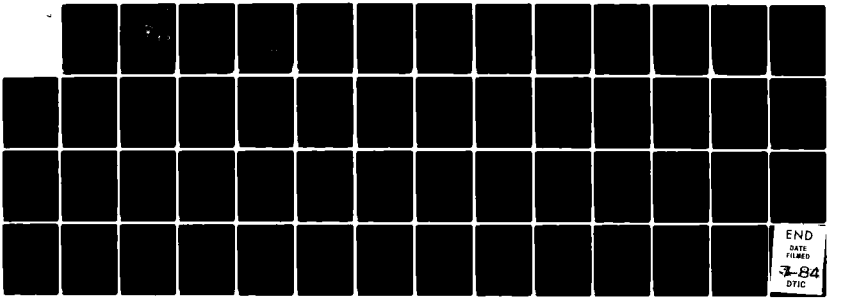
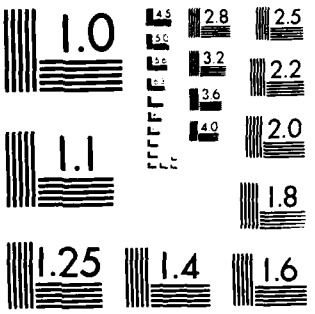
AD-A141 827 PROPOSAL AND DEVELOPMENT PLAN FOR AN AIRCRAFT SYSTEMS INTEGRATION LABORATORY(U) NAVAL POSTGRADUATE SCHOOL MONTEREY CA R W ILER DEC 83 1/1

UNCLASSIFIED F/G 1/3 NL





MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

(2)

NAVAL POSTGRADUATE SCHOOL

Monterey, California

AD-A141 827

DTIC
ELECTE
JUN 5 1984
S D
B

THESIS

PROPOSAL AND DEVELOPMENT PLAN FOR AN AIRCRAFT SYSTEMS INTEGRATION LABORATORY

by

Robert Walter Iler

December 1983

Thesis Advisor: M. D. Hewett

DTIC FILE COPY

Approved for public release; distribution unlimited.

84 06 04 029

UNCLASSIFIED
SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE	READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER	2. GOVT ACCESSION NO. AD-A141 827	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) PROPOSAL AND DEVELOPMENT PLAN FOR AN AIRCRAFT SYSTEMS INTEGRATION LABORATORY	5. TYPE OF REPORT & PERIOD COVERED Master's Thesis December 1983
	6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Robert Walter Iler	8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS Naval Postgraduate School Monterey, California 93943	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS Naval Postgraduate School Monterey, California 93943	12. REPORT DATE December 1983
	13. NUMBER OF PAGES 52
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)	15. SECURITY CLASS. (of this report) UNCLASSIFIED
	15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Aircraft Systems Integration, Active Control Technology, Digital Flight Control, Hardware, Software, Real-time Simulation, Tactical Avionics and Software Test and Evaluation Facility (TASTEF)

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This paper presents a proposal and a plan for the development of an Aircraft Systems Integration Laboratory (ASIL) in the Department of Aeronautics at the Naval Postgraduate School. The paper addresses the current and future benefits of and requirements for the laboratory in the areas of research and education, describes the capabilities of the proposed laboratory, presents a plan for its development, details the costs

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE
S/N 0102-LF-014-6601

20. Abstract continued
involved, and outlines the support required for construction and operation. The purpose of the laboratory will be to conduct research in the man-machine interface problems with aerospace systems and to facilitate the education of Naval aviation officers in the complexities of modern aircraft systems integration.

Accession For
NTIS GRA&I ✓
DTIC TAB ☐
Unannounced ☐
Justification
PER CALL JC
By
Distribution/
Availability Codes
Dist | Avail and/or Special
A-1

Approved for public release; distribution unlimited.

Proposal and Development Plan for an Aircraft Systems Integration Laboratory

by

Robert Walter Iler
Lieutenant Commander, United States Navy
B.S., University of Kansas, 1972
M.S., University of Southern California, 1978

Submitted in partial fulfillment of the
requirements for the degree of

MASTER OF SCIENCE IN AERONAUTICAL ENGINEERING

from the

NAVAL POSTGRADUATE SCHOOL
December 1983

Author: Robert W. Iler

Approved by: Thesis Advisor

Chairman, Department of Aeronautics

Dean of Science and Engineering

ABSTRACT

This paper presents a proposal and a plan for the development of an Aircraft Systems Integration Laboratory (ASIL) in the Department of Aeronautics at the Naval Postgraduate School. The paper addresses the current and future benefits of and requirements for the laboratory in the areas of research and education, describes the capabilities of the proposed laboratory, presents a plan for its development, details the costs involved, and outlines the support required for construction and operation. The purpose of the laboratory will be to conduct research in the man-machine interface problems with aerospace systems and to facilitate the education of Naval aviation officers in the complexities of modern aircraft systems integration.

TABLE OF CONTENTS

		Page
I.	INTRODUCTION	9
II.	OBJECTIVES AND USES OF ASIL	12
III.	BACKGROUND	18
IV.	DESCRIPTION AND CAPABILITIES OF THE AIRCRAFT SYSTEMS INTEGRATION LABORATORY (ASIL)	20
V.	DEVELOPMENT PLAN	22
	A. INTRODUCTION	22
	B. ASIL SYSTEM BLOCK DIAGRAM	22
	C. HARDWARE AND SOFTWARE REQUIREMENTS	24
	1. Hardware: Phase I	29
	2. Software: Phase I	30
	3. Hardware: Phase II	31
	4. Hardware: Phase III	31
	5. Hardware: Phase IV	31
	D. STATEMENT OF SUPPORT	32
	1. Facility Design and Construction	32
	2. Personnel Support	32
	3. Technical Support	33
	4. Installation Plan	33
VI.	COSTS	35
VII.	CONCLUSIONS AND RECOMMENDATIONS	41

APPENDIX A ---------- 43

APPENDIX B ---------- 45

APPENDIX C ---------- 49

BIBLIOGRAPHY ---------- 50

INITIAL DISTRIBUTION LIST ---------- 52

LIST OF TABLES

		Page
1.	FISCAL YEAR 1986 - PHASE I	36
2.	FISCAL YEAR 1987 - PHASE II	37
3.	FISCAL YEAR 1988 - PHASE III	38
4.	FISCAL YEAR 1989 - PHASE IV	39
5.	TOTAL COSTS BY FISCAL YEAR	40

LIST OF FIGURES

Page

1. Three Components of Flight Research ---------- 23
2. ASIL Software Organization ---------- 25
3. ASIL Systems Block Diagram ---------- 26
4. ASIL Hardware Configuration by Phases ---------- 27
5. ASIL Milestones ---------- 28

I. INTRODUCTION

The rapid advancement in computer technology, avionics and digital control systems has greatly enhanced the capabilities of modern aircraft. At the same time it has also significantly increased the job of aircraft design. It is no longer sufficient to build a high performance airframe and fill it with the avionics that it has room to hold. It is now incumbent on the designer to approach the problem from a more complete systems viewpoint. The Naval Postgraduate School has confronted this reality and has done much to provide the Navy with "systems" educated Aeronautical/Avionics Engineers. In order to go forward in this critical area of education a laboratory to instruct, demonstrate, and practice the techniques of systems integration is needed. This thesis will explore the design and utilization of such a laboratory.

The cost of the laboratory development and construction will be $1,751,425.90 in 1983 dollars spread over four fiscal years. The cost for fiscal year 1986 will be $768,375.00 which will produce an operating laboratory capable of limited real-time simulation of tactical systems.

The Aircraft Systems Integration Laboratory (ASIL) will operate in close cooperation with the Tactical Avionics and Software Test and Evaluation Facility (TASTEF)

at the Naval Air Test Center, Patuxent River, Maryland. The intentional similarity between both laboratories will facilitate mutual reinforcement and verification of research results. Additionally, this will contribute to a freer flow of ideas between the academic and the test and evaluation communities.

The laboratory will provide the Naval Postgraduate School and the Navy the opportunity to significantly improve the education of Naval aviation officers in the area of systems integration, engineering, and design and will also provide a superior research facility for students to conduct research in man-machine interface topics in tactical systems integration.

In chapter II the objectives and major uses for ASIL will be discussed. Basically, the laboratory will serve to conduct research and provide hands-on education for the Aeronautics students in the area of system integration. Specific areas are noted and discussed. The background that leads us to the need for ASIL is reviewed in chapter III. The history and justification cited in chapter III leads to the description of capabilities necessary to solve the problem as set forth in chapter IV. Primarily composed of a digital computer based, generic, systems simulator interfaced with the MIL-STD-1553 A/B bus, the laboratory's requisite capabilities are fully outlined in this chapter.

Chapter V is the major section of this work. In it the system development plan is delineated. This includes system block diagrams, required software and hardware, support plans, installation plans, and milestones for timely completion. Costs are covered in their entirety in chapter VI, with chapter VII presenting the pertinent conclusions and, more importantly, the recommendations for follow on work on this project.

II. OBJECTIVES AND USES OF ASIL

The purpose of ASIL will be two-fold:

a. to conduct research in man-machine interface problems with aerospace systems

b. to improve the education of Naval aviation officers in the complexities of modern aircraft systems integration.

A prime use of ASIL will be to support thesis work and sponsored research in a number of related disciplines such as:

a. flying/handling qualities of highly augmented tactical aircraft

b. digital and fly-by-wire systems

c. active control systems

d. integrated control concepts

e. advanced tactical displays (HUD and HDD)

f. advanced simulation techniques

g. redundancy management techniques

Research in these disciplines has expanded rapidly in recent years with the introduction of digital fly-by-wire flight control. This research has been sponsored primarily by the Air Force. In addition, the Navy has developed renewed research interests in these technologies due in large part to an expensive learning experience on the

F/A-18, the first production airplane in the world to employ digital fly-by-wire flight control. A sample of the research projects which could be pursued with a systems integration facility follow:

a) An investigation into the effects of sampling rate on handling qualities of tactical aircraft equipped with digital flight control systems during high gain precision flying tasks.

b) An investigation of the handling qualities criteria for highly augmented flight control systems for the purpose of updating military specifications used in procuring such systems.

c) An investigation into the development of departure prevention systems through the application of active control technology.

d) An evaluation of pilot acceptance of load factor command and pitch rate command control augmentation systems.

e) An investigation of methods for integrating flight control and propulsion control for improved mission effectiveness.

f) An investigation of general control concepts of integrated flight fire control (IFFC), integrated flight weapons control (IFWC), integrated flight trajectory control (IFTC), and integrated flight propulsion control (IFPC) for improved mission effectiveness.

g) An evaluation of the effectiveness of control augmentation systems designed by modern control methods as opposed to classical control methods.

h) An evaluation of model following control as a control augmentation design philosophy for improved mission effectiveness.

i) An investigation of the effectiveness of advanced concepts in adaptive and self learning control.

j) An evaluation of advanced controllers such as side stick controllers, 6-DOF controllers, integrated controllers, and force and deflection controllers.

k) Evaluations of advanced instrument configurations, head up display schemes, and tactical situation displays.

The systems integration laboratory could also be utilized by Aviation Safety Programs to augment course work and to re-create mishaps as an investigative technique.

The laboratory will complement not compete with the Naval Air Systems Command Field Activities, in particular, the Naval Air Test Center which is responsible for the test and evaluation of air weapons systems and the Naval Air Development Center which is responsible for their development.

ASIL will be uniquely suited to conduct scholarly research in systems integration problems with airborne weapons systems. A number of ingredients blend to give the

Aeronautics Department of the Naval Postgraduate School an ideal setting to conduct this research. The presence of a highly technically competent engineering faculty, a student body composed of ambitious, intelligent officers with a wide background of operational experience, including extensive experience in operating and piloting airborne weapon systems, and a military atmosphere in which to conduct this high quality and operationally relevant research, all combine to epitomize the ideal research environment. In addition, this capability and environment will provide long term benefits to the Navy at minimal cost due to the fact that student and computational time are essentially "free" to the sponsoring activity.

Flight Laboratories have operated successfully in several universities where they have been pursued vigorously and operated intelligently. Most notable among those are:

* Princeton
* Mississippi State University (Raspet Flight Research Laboratory)
* CALSPAN (formerly Cornell Research Laboratory)
* University of Kansas

The research being conducted at these facilities is rarely related to Navy topics of concern, whereas the Naval Postgraduate School ASIL facility would be almost totally dedicated to supporting Navy areas of interest.

Additionally, this research will be at minimal cost to the Navy. Furthermore, this facility will stimulate coordinated and cooperative efforts among similar Navy activities such as: Naval Postgraduate School, Naval Test Pilot School, Naval Air Test Center, Naval Air Development Center, and Naval Air Systems Command.

A second prime use of ASIL will be as an instructional laboratory facility in support of the 611 curriculum. 611 students will take a systems design capstone course using ASIL as a design tool in place of the standard traditional capstone aircraft design course taken by all students now. This approach to systems design will parallel very closely the industry approach to tactical aircraft design employed today where the simulator has replaced the wind tunnel in relative importance and use.

By providing the capabilities discussed herein and developing the accompanying coursework and thesis topics the Aeronautics Department can rapidly begin overcoming the current lag in systems engineering education. It is foreseen that with immediate support and nominal funding, aviation officers graduating as early as September 1986 will have the benefits of this project. Furthermore, it is likely that short courses in specific areas such as avionics, software, and systems integration may soon be available for existing aviation program managers or assistants. With the

proper equipment and the systems integration facility a short course can be developed to address a particular aircraft system. The Aircraft Systems Integration Laboratory will serve not only as the educational cornerstone for future Weapon Systems Acquisition Managers and Program Managers but also will provide the capability for specific research on current Naval Aviation problems.

III. BACKGROUND

Over the past decade the cutting edge of aircraft systems technology has evolved from the outside of the airframe to the avionics inside. Airframe and propulsion enhancements take years to transpire. However, changes in avionics, control, and weapons systems technology are occurring at an alarmingly rapid rate. This capability for change is alarming only from the viewpoint of the program manager who must decide on the viability of each new industry innovation. The traditionally educated aeronautical engineer, although strong in structures, propulsion, and aerodynamics, is ill-prepared for the avionics, software, and systems integration necessary in today's aircraft acquisitions. The Aeronautics Curriculum has responded to this need with the 611 curriculum (Aero/Avionics Engineering). This program however, requires significant improvement in course content and appropriate laboratory facilities for both research and instruction in order to keep pace with state-of-the-art technology in systems engineering and integration.

A careful review of the sources noted in the bibliography document how long and how persistently the Aeronautics Department's students have pursued indepth knowledge on the systems integration problem for various aircraft. Furthermore,

these references also serve to illustrate the continuing lack of a satisfactory laboratory for this pursuit.

Over the past year the Department of Aeronautics has studied methods of improving the course content of the Aeronautical Engineering Programs, in particular the 611 program and required updates to laboratory facilities. This study has resulted in new proposed curricula for both the 610 (General Aero Engineering) and 611 programs, which is in internal Naval Postgraduate School review, and the requirement for an Aircraft Systems Integration Laboratory among other required laboratory improvements. This thesis is an initial effort at proposing a system (ASIL) that will begin to update the existing laboratory facilities.

IV. DESCRIPTION AND CAPABILITIES OF THE AIRCRAFT SYSTEMS INTEGRATION LABORATORY (ASIL)

The Aircraft Systems Integration Laboratory will be a digital computer based, real-time, piloted, systems simulator facility with a fixed base, generic tactical cockpit and computer generated displays including tactical head down (HDD) and head up (HUD) displays and visual displays. The laboratory will be composed of:

a. digital computers

b. a fixed base generic tactical cockpit

c. programmable tactical displays

d. variable feel control systems

e. hardware interfaces and buses (MIL-STD-1553 A/B)

f. actual special purpose digital computers (AN/AYK-14)

The ASIL will have the following capabilities:

a. Real-time simulation of the flight characteristics of a wide variety of flight vehicles including conventional and V/STOL tactical aircraft. Integration of the full six degree of freedom nonlinear equations of motions including extensive capability to store aerodynamic data and compute aerodynamic coefficients.

b. Real-time simulation of active control systems including various forms of stability augmentation and control

augmentation, digital control, model reference control and various automatic control functions.

c. Real-time simulations of a wide spectrum of weapons and navigation systems including integrated systems such as Integrated Fire-Flight Control (IFFC), Integrated Flight-Trajectory Control (IFTC), Integrated Flight-Propulsion Control (IFPC), Integrated Flight-Weapons Control (IFWC), and Automatic Terrain Following-Terrain Avoidance Systems (ATF/TA).

d. Simulation of variable control characteristics including control dynamics, function levels, force and deflection gradients, breakout forces and deadbands.

e. Interface with AN/AYK-14 special purpose airborne digital computers.

f. Easy in-house modifications of both software and hardware configuration.

g. Software commonality with Tactical Avionics and Software Test and Evaluation Facility (TASTEF), Naval Air Test Center, Patuxent River, Maryland.

h. Facility capability to support research in the technologies covered previously.

i. Data collection, reduction and analysis of all flight and system parameters.

V. DEVELOPMENT PLAN

A. INTRODUCTION

The following section describes the proposed development plan for the acquisition and installation of ASIL at the Naval Postgraduate School. The following areas will be addressed:

a. Complete Avionics Systems Integration Laboratory (ASIL) system block diagram.

b. Complete list of the hardware and software required, including estimated costs and means of acquisition.

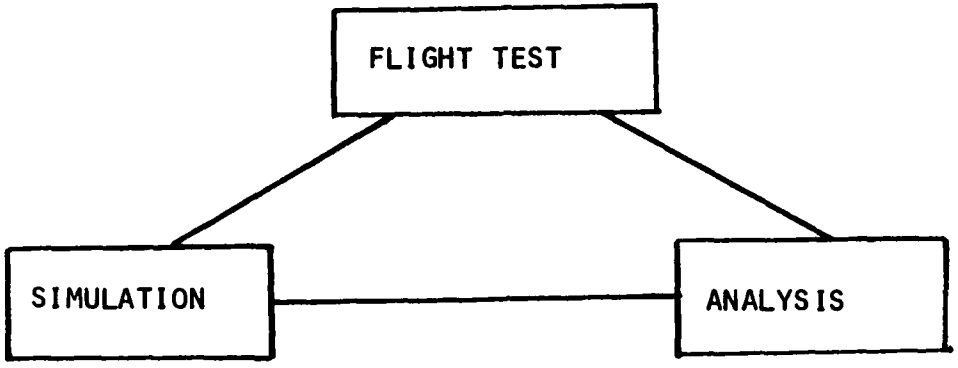
c. A statement of support, detailing the personnel, facilities, and funding required for the life cycle support of the facility.

d. Installation plan, discussing the requirements, costs, and schedule for actual installation.

e. A diagram of milestones to be accomplished over the period from the present to Initial Operational Capability (IOC) (see Figure 5).

B. ASIL SYSTEM BLOCK DIAGRAM

Figure 1 represents the relationship between the three major components of current flight research, i.e., Flight, Analysis, and Simulation. Modern aerospace engineering



THE THREE COMPONENTS OF FLIGHT RESEARCH

FIGURE 1

relies heavily on simulation to conceive, test, analyze, and evaluate state-of-the-art aircraft design alternatives.

ASIL in conjunction with the Naval Air Test Center's Tactical Avionics and Software Test and Evaluation Facility (TASTEF) will perform this level of research on current topics of concern to the Naval Aviation community. Figure 2 depicts the software configuration for the ASIL. The programs and the machines on which they will be run will be discussed later in this paper. Figure 3 presents the total hardware configuration of the proposed facility. The configuration of the facility should remain very nearly identical to the TASTEF configuration in order to permit mutual verification of results and/or problem areas.

C. HARDWARE AND SOFTWARE REQUIREMENTS

All hardware and software for the facility will be acquired in such a manner as to minimize initial acquisition costs, while sacrificing little in research potential. The accompanying list provides a comprehensive table of the required hardware and software and the primary means for acquiring each item. An estimate cost in current dollars is also included for each item. The acquisition is partitioned in phases and tentatively requests one phase per year funding. It should be pointed out however, that Phase I is autonomous in that a full docket of coursework, thesis work, and

ASIL SOFTWARE ORGANIZATION

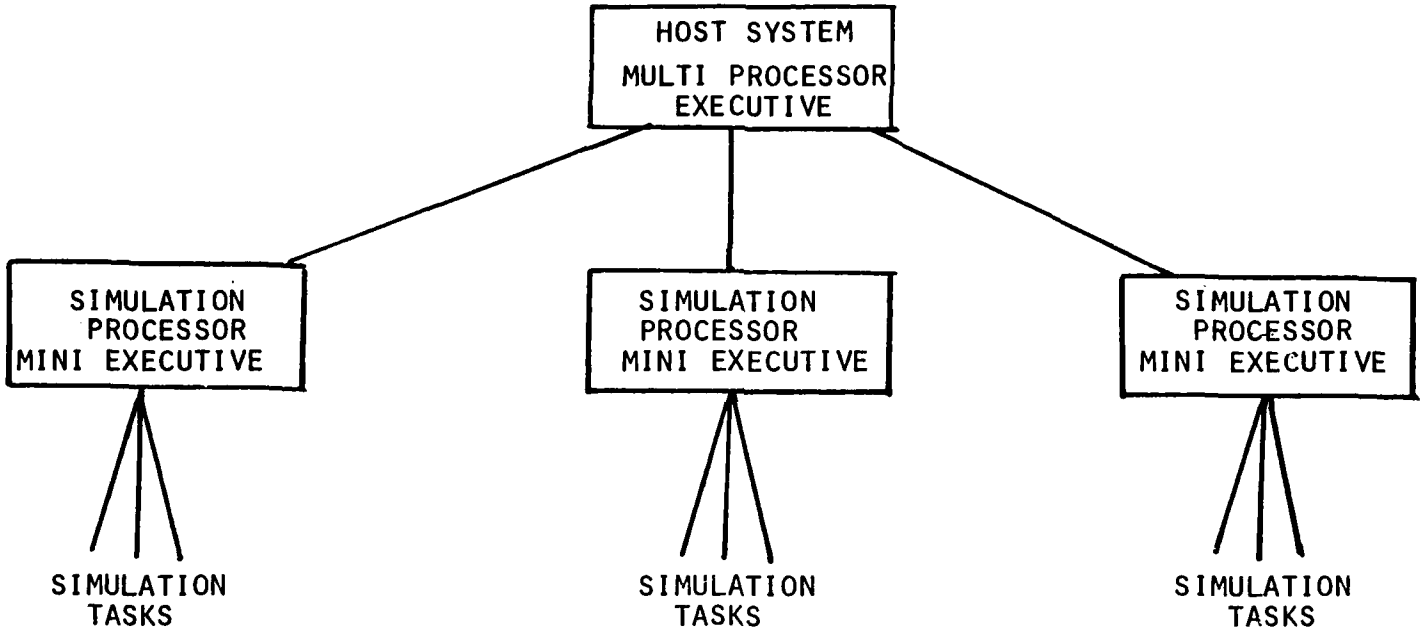


FIGURE 2

AIRCRAFT SYSTEMS INTEGRATION LABORATORY

SYSTEMS BLOCK DIAGRAM

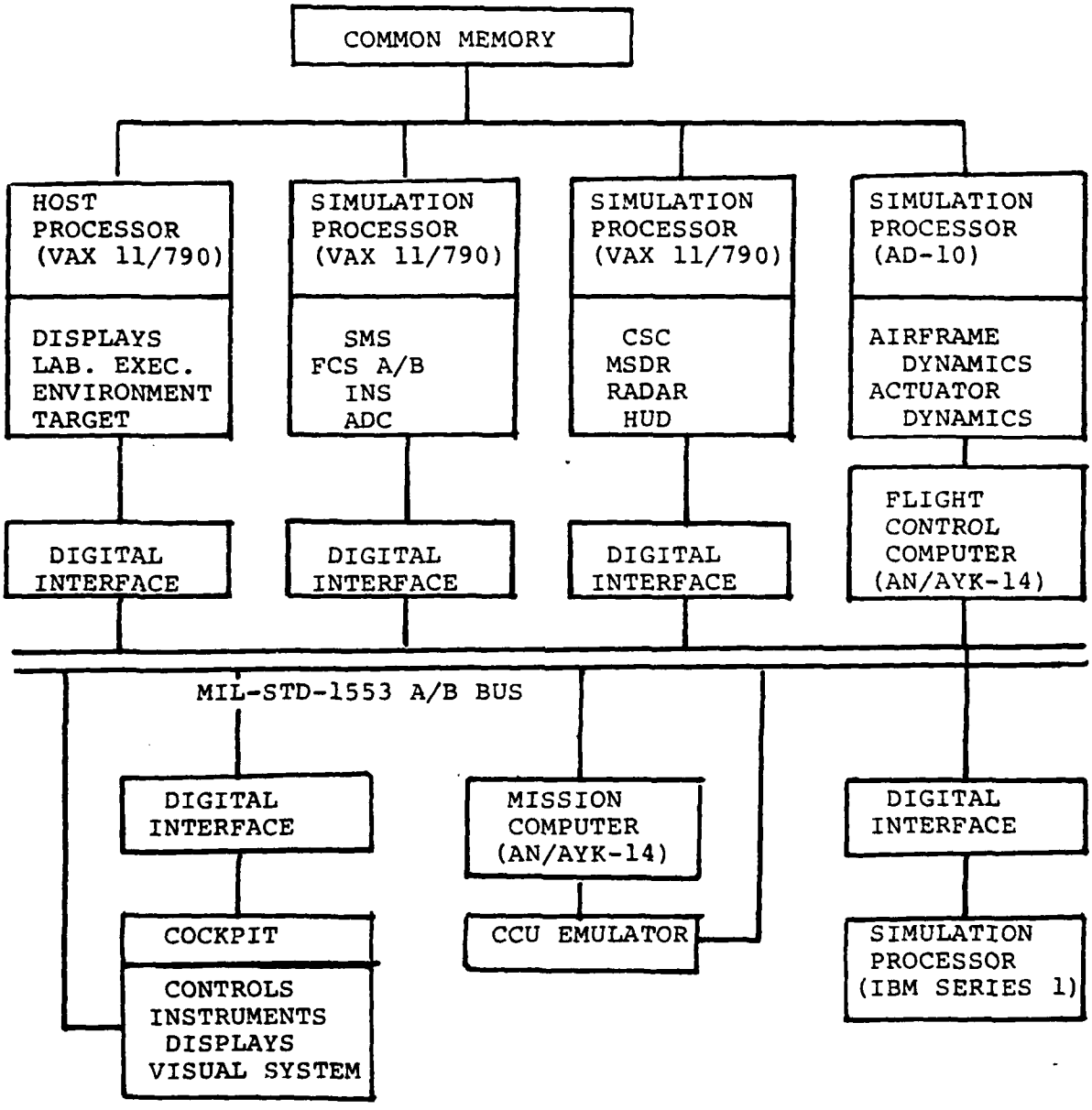


FIGURE 3

AIRCRAFT SYSTEMS INTEGRATION LABORATORY

HARDWARE CONFIGURATION BY PHASES

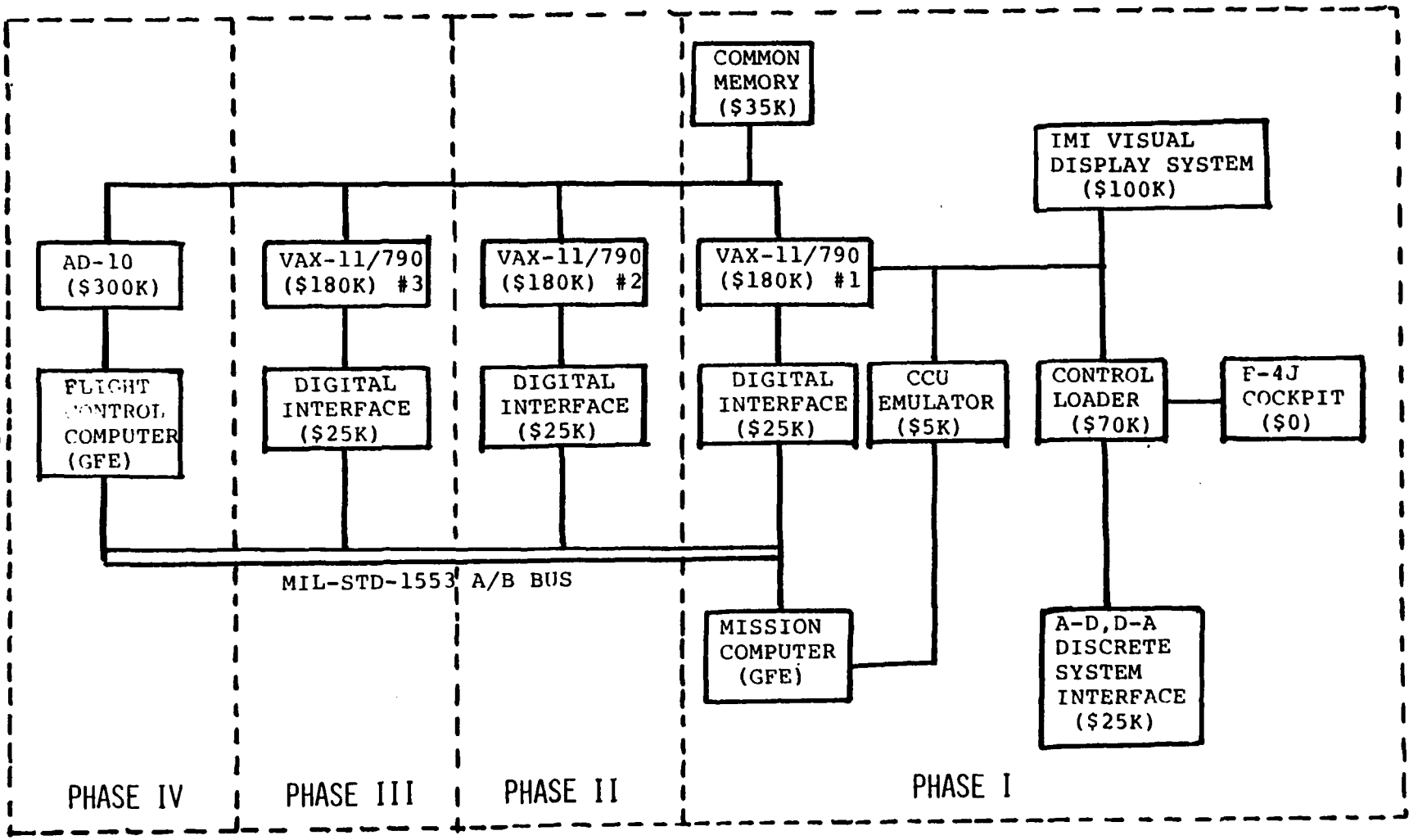


FIGURE 4.

AIRCRAFT SYSTEMS INTEGRATION LABORATORY (ASIL)
MILESTONES

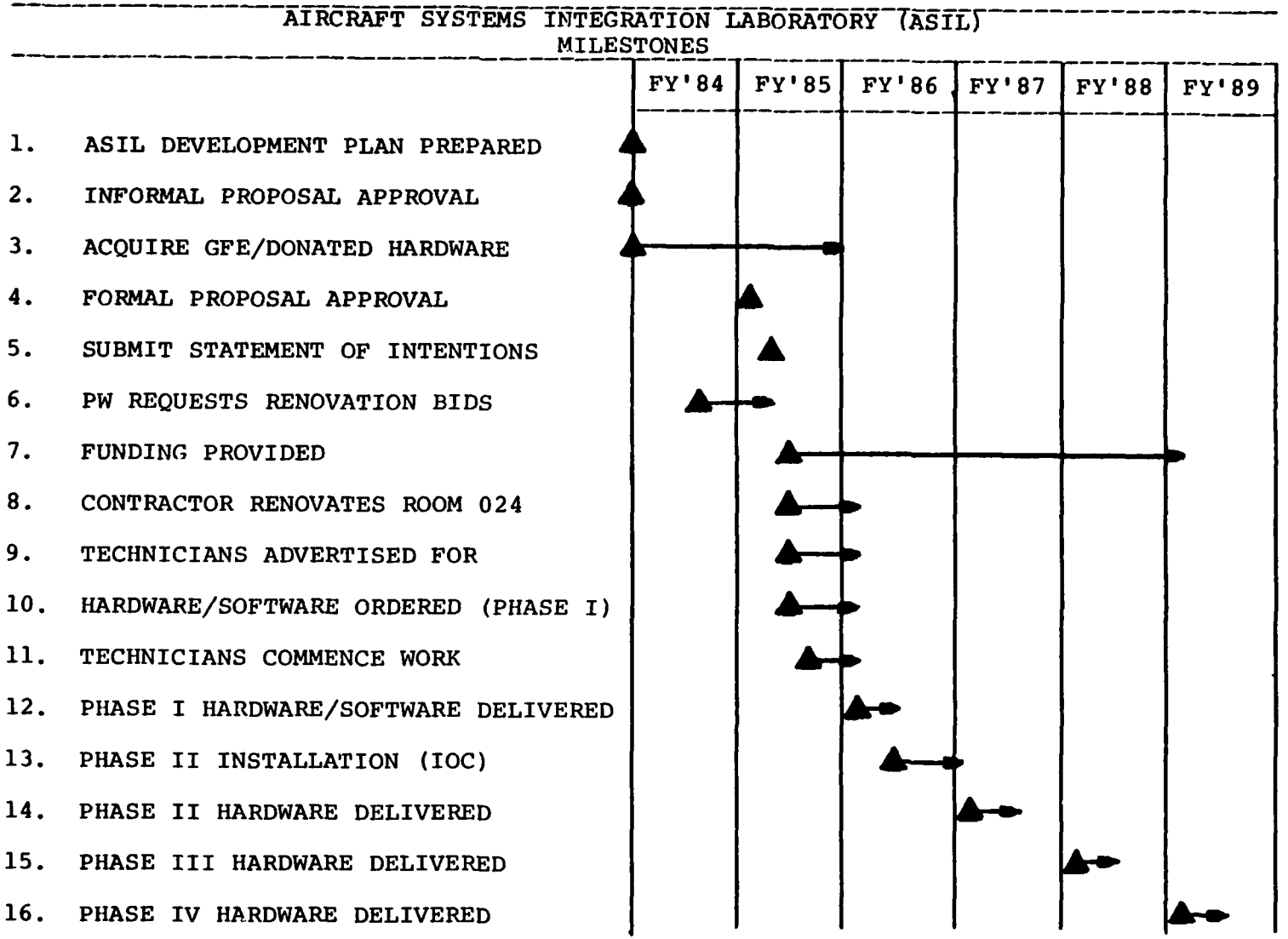


Figure 5

1. HARDWARE: PHASE I

Item		Acquired Via	Cost ($)
a)	Digital Equipment Corp. VAX 11/790 General Purpose Computer System (see Appendix A for cost breakdown)	Open Purchase	$ 273,777.00
b)	Interactive Machines Inc. Visual Display System	Open Purchase	100,000.00
c)	Control Loaders	TASTEF at replication cost	70,000.00
d)	Common Multiport Memory	TASTEF at replication cost	35,000.00
e)	MIL-STD-1553A Bus and Digital Interface	TASTEF at replication cost	25,000.00
f)	Computer Terminals (10 each)	Open Purchase	7,500.00
g)	Analog-to-Digital, Digital -to-Analog Discrete Interface System	TASTEF at replication cost	25,000.00
h)	Miscellaneous Electronic Components and Hardware	Open Purchase/ TASTEF	10,000.00
i)	CCU Emulator (only needed with	TASTEF at replication cost	5,000.00
j)	Cockpits (single seat and Multi-seat)	NPS (single seat) NASA Ames (multi-seat)	0.00 0.00
k)	Computer Maintenance Contract	Open Purchase/ TASTEF	27,377.00
l)	OPTIONAL: 6-DOF Hydraulically operated, motion base	NASA Ames	0.00
TOTAL COST			$ 578,654.00

2. SOFTWARE: PHASE I

Item	Acquired Via	Cost ($)
a) Display Software	TASTEF	0.00
b) Executive Program	TASTEF	0.00
c) Avionics Models	TASTEF	
(1) Radar		
(2) Inertial Navigation		
(3) Air Data Computer		
(4) Stores Management System		
(5) ESS		
(6) CSC		
d) Aerodynamic Models	Simulation and Tech. Group (NATC)	0.00
(1) F-4S		
(2) F-14A		
(3) F/A-18		
(4) AV-8B		
(5) X-29		
e) Control Loader Software	TASTEF	0.00
f) SMART (Environmental Model)	NASA Ames/ Simulation and Tech. Group (NATC)	0.00
(1) Atmosphere Model		
(2) Earth Model (flat or round)		
(3) Integration Routines (position, velocity, acceleration)		
(4) Axis Translations		
(5) Wind Turbulence Model		
(6) Landing Aids - ILS		
(7) Random Number Generator		
(8) Z-Transforms		
(9) Trim Software		
(10) Function Table Processor		
TOTAL COST		0.00

NOTE: Software required primarily for VAX 11/790 operation (i.e., VMS, DEC Writer, Fortran) is included in VAX 11/790 Phase I breakdown.

3. HARDWARE: PHASE II

Item	Acquired Via	Cost ($)
a) Digital Equipment Corp. VAX 11/790 General Purpose Computer System (see Appendix A for cost breakdown)	Open Purchase	$ 180,030.00
b) MIL-STD-1553 A/B Bus and Digital Interface	TASTEF at replication cost	25,000.00
TOTAL COST		$ 205,030.00

4. HARDWARE: PHASE III

Item	Acquired Via	Cost ($)
a) Digital Equipment Corp. VAX 11/790 General Purpose Computer System (see Appendix A for cost breakdown)	Open Purchase	$ 180,030.00
b) MIL-STD-1553 A/B Bus and Digital Interface	TASTEF at replication cost	25,000.00
TOTAL COST		$ 205,030.00

5. HARDWARE: PHASE IV

Item	Acquired Via	Cost ($)
a) Applied Dynamics D-10 General Purpose Computer System	Open Purchase	$ 300,000.00
TOTAL COST		$ 300,000.00

research can begin with the procurement and installation of this phase (see Figure 4).

D. STATEMENT OF SUPPORT

The support required for ASIL will fall into four categories:

- facility design and construction
- personnel
- technical
- funding

1. Facility Design and Construction

The Naval Postgraduate School currently has a building that will provide an ideal location and adequate space for the systems integration facility. Currently, room 024 of Halligan Hall is part of the present Aeronautics Department facilities and can be made available for ASIL equipment with a minimum of external assistance. Providing the ASIL with satisfactory air-conditioning, lighting, and power will be required during the early stages of installation. This will require funding in order to contract for this construction (see Appendix B and Fiscal Year 1986 - Phase I funding).

2. Personnel Support

The personnel required to provide year around life-cycle support to the ASIL facility include the existing staff technicians and two additional civilian positions; a

GS-11 Computer Specialist position and a GS-7 Engineering Technician position. These positions must be filled in the year of the major equipment purchases (Fiscal Year 1986) as presented herein. Funding to support these positions is included in this proposal. Support required prior to the year of major equipment purchases can be provided by the personnel presently assigned to the department.

3. Technical Support

Technical support and guidance of the facility will be continuously provided by the Aeronautics Department faculty and staff. The Naval Test Center, Patuxent River has agreed to provide not only installation and facility design support but also continued guidance and consultation throughout the life of the facility. Additionally, the NASA Ames Simulation branch has agreed to provide technical guidance and to establish a program for related, thesis student, experience tours at their facility. A well woven working relationship between these facilities and ASIL is beneficial to the Navy as well as all concerned.

4. Installation Plan

Actual installation of the initial equipment acquisition will not begin until fiscal year 1986. However, prior to that time several tasks will be accomplished. Equipment and supplies that are currently available at little or no cost will be acquired and tested for project suitability.

A source of preliminary, but nominal funding for this phase may be requested under the Naval Postgraduate School Foundation Research program through the project advisor (Dr. Hewett). Under this category of equipment and supplies fall such items as:

- cockpits
- surplus instrumentation
- control sticks
- motion base
- software
- surplus computing equipment

When funding has been provided for the initial purchase of equipment it will be necessary to coordinate with both TASTEF and Digital Equipment Corporation on a suitable time-table for the major installation. Naturally, as noted in Appendix B, Public Works will be notified to promulgate the room renovation contract as soon as possible. After this initial installation period future additions to the laboratory will be handled by in-house means.

VI. COSTS

The following tables provide a detailed breakdown of the estimated costs involved in establishing the laboratory and operating it over the period Fiscal Year 1986 through 1989. Each table lists the best estimates currently available from the respective supplier. All estimates are in 1983 dollars. The equipment marked with an asterisk (*) is both estimated by and obtainable through the Tactical Avionics and Software Test and Evaluation Facility (TASTEF) at Patuxent River, Maryland. Points of contact for this and other facilities referred to in this thesis are listed in Appendix C.

TABLE I

FISCAL YEAR 1986 - PHASE I

1.	Salaries	
	a. Support Personnel	
	1) Engineering Technician GS-7 (1 man year)	$ 13,230.00
	2) Computer Specialist GS-11 (1 man year)	29,491.00
	b. Total Labor Charges	$ 42,721.00
	NOTE: The costs above include direct benefits such as insurance, retirement, and earned annual leave and sick leave.	
2.	Equipment and Supplies	
	a. Digital Equipment Corp. VAX 11/790 General Purpose Digital Computer	$273,777.00
	b. Interactive Machines Inc. Visual Display System	100,000.00
	*c. Control Loaders	70,000.00
	*d. Common Multiport Memory	35,000.00
	*e. MIL-STD-1553 A/B Bus and Digital Interface	25,000.00
	f. Computer Terminals (10 each)	7,500.00
	*g. A-D, D-A, Discrete System Interface	25,000.00
	h. Miscellaneous Electronic Components and Hardware Supplies	100,000.00
	*i. Computer Control Unit (CCU) Emulator	5,000.00
	j. Computer Maintenance Contract	27,377.00
	k. Installation Contract	50,000.00
	l. Room Renovation (see Appendix B for cost breakdown)	97,000.00
	NOTE: Unless specifically stated to the contrary, acceptance and fiscal support of the proposal authorizes approval of the procurement of equipment as indicated in the proposal and retention of title to that equipment by the Naval Postgraduate School.	
TOTAL ESTIMATED COSTS FOR FISCAL YEAR 1986		$768,375.00

TABLE 2

FISCAL YEAR 1987 - PHASE II

1.	Salaries	
	a. Support Personnel	
	1) Engineering Technician GS-7 (1 man year)	$ 20,924.00
	2) Computer Specialist GS-11	30,965.50
	b. Total Labor Charges	$ 51,889.90
	NOTE: The costs above include direct benefits such as insurance, retirement, and earned annual leave and sick leave.	
2.	Equipment and Supplies	
	a. Digital Equipment Corp. VAX 11/790 General Purpose Computer	$180,030.00
	*b. MIL-STD-1553 A/B Bus and Digital Interface	25,000.00
	c. Miscellaneous Equipment and Supplies	10,000.00
	d. Computer Maintenance Contract	27,377.00
	e. Total Equipment and Supplies	$242,407.00
	NOTE: Unless specifically stated to the contrary, acceptance and fiscal support of the proposal authorizes approval of the procurement of equipment as indicated in the proposal and retention of title to that equipment by the Naval Postgraduate School.	
TOTAL ESTIMATED COSTS FOR FISCAL YEAR 1987		$294,296.90

TABLE 3

FISCAL YEAR 1988 - PHASE III

1.	Salaries	
	a. Support Personnel	
	1) Engineering Technician GS-7 (1 man year)	$ 21,971.00
	2) Computer Specialist GS-11 (1 man year)	32,514.00
	b. Total Labor Charges	$ 54,485.00
	NOTE: The costs above include direct benefits such as insurance, retirement, and earned annual leave and sick leave.	
2.	Equipment and Supplies	
	a. Digital Equipment Corp. VAX 11/790 General Purpose Computer	$180,030.00
	*b. MIL-STD-1553 A/B Bus and Digital Interface	25,000.00
	c. Miscellaneous Equipment and Supplies	10,000.00
	d. Computer Maintenance Contract	27,377.00
	e. Total Equipment and Supplies	$242,407.00
	NOTE: Unless specifically stated to the contrary, acceptance and fiscal support of the proposal authorizes approval of the procurement of equipment as indicated in the proposal and retention of title to that equipment by the Naval Postgraduate School.	
TOTAL ESTIMATED COSTS FOR FISCAL YEAR 1988		$296,892.00

TABLE 4

FISCAL YEAR 1989 - PHASE IV

1.	Salaries	
	a. Support Personnel	
	1) Engineering Technician GS-7 (1 man year)	$ 21,971.00
	2) Computer Specialist GS-11 (1 man year)	32,514.00
	b. Total Labor Charges	$ 54,485.00
	NOTE: The costs above include direct benefits such as insurance, retirement, and earned annual leave and sick leave.	
2.	Equipment and Supplies	
	a. Applied Dynamics AD-10 High Speed Computer	$300,000.00
	b. Miscellaneous Equipment and Supplies	10,000.00
	c. Computer Maintenance Contract	27,377.00
	d. Total Equipment and Supplies	$337,377.00
	NOTE: Unless specifically stated to the contrary, acceptance and fiscal support of the proposal authorizes approval of the procurement of equipment as indicated in the proposal and retnention of title to that equipment by the Naval Postgraduate School.	
TOTAL ESTIMATED COSTS FOR FISCAL YEAR 1989		$391,862.00

TABLE 5

TOTAL COSTS BY FISCAL YEAR

Fiscal Year 1986 - Phase I	$ 768,375.00
Fiscal Year 1987 - Phase II	$ 294,296.90
Fiscal Year 1988 - Phase III	$ 296,892.00
Fiscal Year 1989 - Phase IV	$ 391,862.00
TOTAL	$1,751,425.90

VII. CONCLUSIONS AND RECOMMENDATIONS

The major return seen for the investment in this project is the inevitable reduced costs of procurement and the improved products through educated and informed buyers. The Aeronautics Department of the Naval Postgraduate School is the only Navy facility with the unique blend of ingredients necessary to actually educate future and even present Weapon Systems Acquisition Managers and Program Managers.

The value of a facility analogous to the prestigious civilain Flight Research Laboratories previously mentioned, which will be under thd direct control of the Naval Air Systems Command, is unequivocal. The Navy will have a low cost and easily accessible laboratory to pursue current systems integration problems with precisely the officers who will be making critical decisions on similar systems later in their careers. Taking into account the recent position with regards to "new systems instead of new airframes" stated by the Secretary of the Navy, this investment in solutions to the systems integration problems of the future may simply be prudent program management.

This thesis has attempted to outline a general "plan-of-attack" for the installation and implementation of a fully capable Aircraft Systems Integration Laboratory. The

problem confronted herein is both complex and dynamic. Within the short timeframe of the author's involvement numerous changes have both compounded and simplified the solution. Therefore, it is evident that much follow-on work will branch forth from this slender effort. With this in mind, it is recommended that future students be encouraged to focus their efforts on but a small segment of the project. Additionally, whenever possible, each participant should visit the TASTEF facility at NATC in order to solidify in their mind the objective. Although ASIL will not become a clone of TASTEF, its objectives are so consistent with our own that a continuing working relationship will be highly beneficial to both parties.

APPENDIX A

1. Digital Equipment Corporation - VAX 11/790 General Purpose Computer System

Equipment	Cost
a) HSC 50	$ 32,500.00
b) HSC 50x	7,100.00
c) RA 81	19,000.00
d) RA 60	15,000.00
e) 16 Asychronous Lines	7,990.00
f) VAX 11/790 (1 each)	180,000.00
g) Disk Interface	20,000.00
h) DEC Writer	2,800.00
i) Memory	9,000.00
j) VMS	20,000.00
k) FORTRAN	8,700.00
Subtotal	$ 322,090.00
(minus 15 percent GSA discount)	48,313.00
TOTAL System Cost	$ 273,777.00

2. Additional VAX 11/790:

a) VAX 11/790	$ 180,000.00
b) Disk Interface	20,000.00
c) DEC Writer	2,800.00

d) Memory	9,000.00
Subtotal	$ 211,800.00
(minus 15 percent GSA discount)	31,770.00
TOTAL	$ 180,030.00

APPENDIX B

Public Works Cost Estimate for the Renovation of Halligan Hall, Room 024 (Room 024, Bldg 234):

The attached estimate was prepared by Mr. George Nelson of the Naval Postgraduate School Public Works Department. The projected costs were in 1983 dollars with escalation factors of eight percent for both 1984 and 1985. The estimate was based on a start date of early 1985. In order to provide adequate time for bids to be promulgated and received, allow approximately six months lead time prior to start of construction. Additionally, prior to release of the project for bids, the Aeronautics Curriculum Officer must present a statement of intentions for the project to the school facility planning committee.

NC4(436)/vlo
29 November 1983

MEMORANDUM

From: Dave Tedrow, Code 436
To: Dr. Marle Hewett, Code 31

Subj: Aviation Computer Lab 024, Bldg. 234

Encl: (1) Budget Cost Estimate for Aviation Computer Lab 024, Bldg. 234; Total - $97,000.

1. Enclosure (1) has been prepared and is forwarded for your information as requested by LCDR Robert Iler, Aeronautics Department.

DAVE TEDROW

Copy to:
LCDR Iler

CONSTRUCTION SCHEDULED FOR LATE FY 85 BID IN MID FY 85

NAVFAC 11613/7 (1-78)
Supersedes NAVDOCKS 2417 and 2417A

COST ESTIMATE

DATE PREPARED: 23 Nov 83

SHEET 1 OF 2

ACTIVITY AND LOCATION: NAVAL POSTGRADUATE SCHOOL, MONTEREY, CA 93940

PROJECT TITLE: AVIATION COMPUTER LAB 024, BLDG. 234

CONSTRUCTION CONTRACT NO.:

ESTIMATED BY: GEORGE NELSON

STATUS OF DESIGN: ☐ PED ☐ 30% ☐ 100% ☐ FINAL ☒ Other (Specify) Budget

IDENTIFICATION NUMBER:

CATEGORY CODE NUMBER:

JOB ORDER NUMBER:

ITEM DESCRIPTION	QUANTITY NUMBER	QUANTITY UNIT	MATERIAL COST UNIT COST	MATERIAL COST TOTAL	LABOR COST UNIT COST	LABOR COST TOTAL	ENGINEERING ESTIMATE UNIT COST	ENGINEERING ESTIMATE TOTAL
REINSTALL DOUBLE DOORS (SWING OUT)	2	EA					350.00	350.00
REMOVE FLUORESCENT INDUST. FIXTURES	10	EA					25.00	250.00
REMOVE UNIT HEATER & PIPING	1	EA					150.00	150.00
CORE DRILL THRU WALL & SLEEVE	2	EA					100.00	100.00
SUSPENDED T-BAR CEILING 9" height above raised deck	850	SF					1.75	1,487.00
INSULATION IN CEILING	850	SF					.50	425.00
RAISED PEDESTAL COMPUTER FLOOR ALUMINUM 1'-6"	850	SF					11.00	9,350.00
RAMP	30	SF					20.00	600.00
RAMP RAILING	10	LF					35.00	350.00
STEP FOR EXIT DOOR	3	LF					20.00	60.00
SEALING FOR DOORS	3	EA					50.00	150.00
FUR UP WINDOWS TO SUSPENDED CEILING	50	SF					5.00	250.00
PAINTING	1200	SF					.60	720.00
LIGHTING FIXTURES IN T-BAR CEILING	10	EA					300.00	3,000.00
EMERGENCY LIGHTING	1	EA					300.00	300.00
HALON FIRE EXTINGUISHER SYSTEM	100	Pounds					68.00	6,800.00
FIRE ALARM SYSTEM	LS	JOB					1,000.00	1,000.00

S/N 0105-LF-010-1335

Enclosure 1

NAVFAC 11013/7 (1-78)
Supersedes NAVDOCKS 2417 and 2417A

COST ESTIMATE

DATE PREPARED: 23 Nov 83

SHEET 2 OF 2

ACTIVITY AND LOCATION: NAVAL POSTGRADUATE SCHOOL, MONTEREY, CA 93940

CONSTRUCTION CONTRACT NO.:

IDENTIFICATION NUMBER:

ESTIMATED BY: GEORGE NELSON

CATEGORY CODE NUMBER:

PROJECT TITLE: AVIATION COMPUTER LAB 024, BLDG. 234

STATUS OF DESIGN: [ ] PED [ ] 30% [ ] 100% [ ] FINAL [X] Other (Specify) Budget

JOB ORDER NUMBER:

ITEM DESCRIPTION	QUANTITY NUMBER	QUANTITY UNIT	MATERIAL COST UNIT COST	MATERIAL COST TOTAL	LABOR COST UNIT COST	LABOR COST TOTAL	ENGINEERING ESTIMATE UNIT COST	ENGINEERING ESTIMATE TOTAL
AIR-CONDITIONING CHILLER	15	TON					1,500.00	22,500.00
AIR CONDITIONING CIRC. UNIT & INTAKE DUCT	1	EA					6,000.00	6,000.00
DOOR VENT BAROMETRIC LOUVER DAMPER	1	EA					150.00	150.00
SPECIAL OUTLETS	15	EA					150.00	2,250.00
DUPLEX OUTLETS 120v	10	EA					50.00	500.00
MAIN DISCONNECT SWITCH BOX	1	EA					1,000.00	1,000.00
PANEL CONNECTED	1	EA					2,000.00	2,000.00
CIRCUIT BREAKERS	20	EA					50.00	1,000.00
6" CONCRETE A/C PAD	24	SF					5.00	120.00
COVER WINDOWS W/LAMIN. ALUM. FIBERBOARD	185	SF					2.00	370.00
WALL AIR INTAKE FAN & DUCT	1	EA					400.00	400.00
HAULING & CLEANUP	LS	JOB					1,000.00	1,000.00
SUB-TOTAL								62,732.00
CONTRACTORS OH & PROFIT	25	%						15,683.00
CONTINGENCY	6	%						4,705.00
ESCALATION FACTOR FOR 84	8	%						6,650.00
ESCALATION FACTOR FOR 85	8	%						7,182.00
GRAND TOTAL								96,952.00

S/N 0105-LF-010-1335

SAY 97,000.00

Enclosure 1

APPENDIX C

Points of contact for Aircraft Systems Integration Laboratory (ASIL) project:

1. Hewett, M. D., Ph.D., Adjunct Professor and ASIL Project Manager, Naval Postgraduate School, Monterey, California, 93943, (408)646-2936.
2. Iler, R. W., LCDR USN, Development Plan Author, Naval Plant Representative, Westinghouse Company, Baltimore, Maryland, (301)765-3890.
3. Cruce, A. C., Director, Tactical Avionics and Software Test and Evaluation Facility (TASTEF), Systems Engineering Test Directorate, Naval Air Test Center, Patuxent River, Maryland, 20670, (301)863-4787.
4. Golesh, D., Senior Sales Representative, Digital Equipment Corporation, 2525 Augustine Drive, Santa Clara, California, 95051, (408)748-4443 or 727-0200.
5. Brocker, D., Assistant Chief of Space Science Division, N245-1, NASA Ames, Moffett Field, California, 94035, (415)965-5536.
6. Cook, A. M., Assistant Division Chief of Simulation, Code FS, N243-1, NASA Ames, NAS Moffett Field, California, 94035, (415)965-5162.
7. Tedrow, D., Public Works, Code 436, Naval Postgraduate School, Monterey, California, 93943, (408)646-2531.

BIBLIOGRAPHY

Ammerman, L. R., Evaluation of an Integrated Electronic Instrument Display for Helicopter Hover Operations Using a Six-Degree-of-Freedom Fixed-Base Simulation, Master's Thesis, Naval Postgraduate School, Monterey, California, March 1975.

Cruce, A. C., A Generic Approach to Simulation/Support Facility Design, Systems Engineering Test Directorate, Naval Air Test Center, Patuxent River, Maryland, July 1983 (unpublished).

Gibson, R. A., Development of a Fixed Base Visual Approach and Landing Simulator, Master's Thesis, Naval Postgraduate School, Monterey, California, March 1972.

Hewett, M. D., Departure Prevention for Tactical Aircraft Through Active Control Technology, Proposal for Research, Naval Postgraduate School, Monterey, California, May 1983 (unpublished).

Hewett, M. D. and Iler, R. W., Proposal and Development Plan for Aircraft Systems Integration Laboratory, Technical Proposal, Naval Postgraduate School, Monterey, California, September 1983 (unpublished).

Hoxie, S. S., The Implementation of a Fixed Base Helicopter Simulation in the Investigation of an Automatic Scan System, Engineer's Thesis, Naval Postgraduate School, Monterey, California, March 1974.

Huckemeyer, M. R., Incorporation of the Six Dimensional Linearized Equations of Motion with a Variable Stability Flight Simulator, Master's Thesis, Naval Postgraduate School, Monterey, California, September 1971.

Johnson, J. A., Study of a C-11 Instrument Flight Trainer as a Variable Stability Model and Simulator for Studies in Flight Dynamics, Master's Thesis, Naval Postgraduate School, Monterey, California, December 1967.

Newell Jr., R. B., Design Parameters for a Visual Presentation Aircraft Simulator, Master's Thesis, Naval Postgraduate School, Monterey, California, March 1971.

Sweeney, C. J., Conversion of AC-11B Instrument Flight Trainer into a Variable Stability Flight Simulator, Master's Thesis, Naval Postgraduate School, Monterey, California, September 1968.

Willetts Jr., L. J., An Investigation of the Longitudinal Handling Qualities of a Variable Stability Flight Simulator, Engineer's Thesis, Naval Postgraduate School, Monterey, California, June 1969.

INITIAL DISTRIBUTION LIST

		No. Copies
1.	Defense Technical Information Center Cameron Station Alexandria, Virginia 22314	2
2.	Library, Code 0142 Naval Postgraduate School Monterey, California 93943	2
3.	Department Chairman, Code 67 Department of Aeronautics Naval Postgraduate School Monterey, California 93943	1
4.	Professor M. D. Hewett, Code 67He Department of Aeronautics Naval Postgraduate School Monterey, California 93943	5
5.	Dr. Andrew Cruce, Code SY30 Naval Air Test Center Patuxent River, Maryland 20670	1
6.	LCDR Robert Walter Iler, USN PMR-272 Naval Air Systems Command Arlington, Virginia 20361	3
7.	Mr. A. M. Cook N243-1, NASA Ames NAS Moffett Field Moffett Field, California 94305	1